

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-084368
 (43)Date of publication of application : 30.03.2001

(51)Int.Cl. G06T 5/20
 H04N 5/21

(21)Application number : 11-261706 (71)Applicant : SONY CORP
 (22)Date of filing : 16.09.1999 (72)Inventor : KONDO TETSUJIRO
 ANDO KAZUTAKA

(54) DATA PROCESSOR DATA PROCESSING METHOD AND MEDIUM

(57)Abstract:

PROBLEM TO BE SOLVED: To improve the processing performance of data.
 SOLUTION: For respective directions D1D2...D16 whose start point is a center pixel based on the waveform characteristics (characteristics of pixel value) of an SD pixel present in the direction the SD pixel for finally constituting a tap is decided. That is for the respective directions Di based on the waveform characteristics of an SD image present in the direction the position of the SD pixel for constituting the tap present in the direction is moved.

CLAIMS

[Claim(s)]

[Claim 1] A data processing device which processes input data and predicts output data to the input data comprising:

A determination means to determine two or more data extracted from said input data based on the waveform characteristic of said input data.

An extraction means to extract two or more data from said input data according to determination in said determination means about attention output data which is said output data which is going to calculate a predicted value.

A prediction means which calculates a predicted value of said attention output data based on two or more data extracted in said extraction means.

[Claim 2] Based on two or more data extracted in said extraction means class sorting is performed about said attention output data The data processing device

according to claim 1 wherein said prediction means calculates a predicted value of said attention output data using a predetermined prediction coefficient corresponding to said class code including further a class sorting means to output a corresponding class code.

[Claim 3] The data processing device according to claim 2 wherein said prediction means linearity-primary-predicts said attention output data using said prediction coefficient.

[Claim 4] The data processing device according to claim 3 wherein said prediction means linearity-primary-predicts said attention output data using said prediction coefficient and two or more data extracted in said extraction means.

[Claim 5] The data processing device according to claim 2 including further a prediction coefficient memory measure which has memorized said prediction coefficient for said every class code.

[Claim 6] The data processing device according to claim 1 wherein said determination means detects an extremum of said input data and determines two or more data extracted from said input data based on the detection result.

[Claim 7] The data processing device according to claim 1 wherein said determination means calculates a difference value of said input data and determines two or more data extracted from said input data based on the result of an operation.

[Claim 8] The data processing device according to claim 1 wherein said determination means determines two or more data which calculates an error of said input data to a function which approximates said input data and is extracted from said input data based on the result of an operation.

[Claim 9] The data processing device according to claim 1 wherein said input data and output data are image data.

[Claim 10] The data processing device according to claim 9 wherein said extraction means extracts a pixel which exists on the outskirts spatially or in time from image data as said input data to a pixel as said attention output data.

[Claim 11] A data processing method which processes input data and predicts output data to the input data comprising:

A determination step which determines two or more data extracted from said input data based on the waveform characteristic of said input data.

An extraction step which extracts two or more data from said input data according to determination in said determination step about attention output data which is said output data which is going to calculate a predicted value.

A prediction step which calculates a predicted value of said attention output data based on two or more data extracted in said extraction step.

[Claim 12] A medium which makes a computer execute a program for performing data processing which processes input data and predicts output data to the input data comprising:

A determination step which determines two or more data extracted from said input data based on the waveform characteristic of said input data.

An extraction step which extracts two or more data from said input data according to determination in said determination step about attention output data which is said output data which is going to calculate a predicted value.

A prediction step which calculates a predicted value of said attention output data based on two or more data extracted in said extraction step.

[Claim 13] A data processing device which learns a prediction coefficient used for predicting output data [as opposed to / process input data and / the input data] characterized by comprising the following.

A creating means which generates student data which serves as a student from teacher data which serves as a teacher for study of said prediction coefficient.

A determination means to determine two or more data extracted from said student data based on the waveform characteristic of said student data.

An extraction means to extract two or more data from said student data according to determination in said determination means about attention teacher data which is said teacher data which is going to calculate a predicted value.

A calculating means which calculates said prediction coefficient based on two or more data extracted in said extraction means.

[Claim 14] Based on two or more data extracted in said extraction means class sorting is performed about said attention teacher data. The data processing device according to claim 13 characterized by said calculating means containing ** in quest of said prediction coefficient using two or more data extracted in said extraction means for said every class code including further a class sorting means to output a corresponding class code.

[Claim 15] The data processing device according to claim 13 wherein said calculating means calculates said prediction coefficient for said teacher data to be obtained by linearity primary prediction.

[Claim 16] The data processing device according to claim 15 wherein said calculating means calculates said prediction coefficient for said teacher data to be obtained by linearity primary prediction using two or more data extracted in said extraction means.

[Claim 17] The data processing device according to claim 13 wherein said determination means detects an extremum of said student data and determines two or more data extracted from said student data based on the detection result.

[Claim 18] The data processing device according to claim 13 wherein said determination means calculates a difference value of said student data and determines two or more data extracted from said student data based on the result of an operation.

[Claim 19] The data processing device according to claim 13 wherein said determination means determines two or more data which calculates an error of said student data to a function which approximates said student data and is extracted from said student data based on the result of an operation.

[Claim 20] The data processing device according to claim 13 wherein said student

data and teacher data are image data.

[Claim 21]The data processing device according to claim 20wherein said extraction means extracts a pixel which exists on the outskirts spatially or in time from image data as said student data to a pixel as said attention teacher data.

[Claim 22]A data processing method which learns a prediction coefficient used for predicting output data [as opposed to / process input data and / the input data] characterized by comprising the following.

A generation step which generates student data which serves as a student from teacher data which serves as a teacher for study of said prediction coefficient.

A determination step which determines two or more data extracted from said student data based on the waveform characteristic of said student data.

An extraction step which extracts two or more data from said student data according to determination in said determination step about attention teacher data which is said teacher data which is going to calculate a predicted value.

An arithmetic step which calculates said prediction coefficient based on two or more data extracted in said extraction step.

[Claim 23]A medium which makes a computer execute a program for performing data processing which learns a prediction coefficient used for predicting output data [as opposed to / process input data and / the input data] characterized by comprising the following.

A generation step which generates student data which serves as a student from teacher data which serves as a teacher for study of said prediction coefficient.

A determination step which determines two or more data extracted from said student data based on the waveform characteristic of said student data.

An extraction step which extracts two or more data from said student data according to determination in said determination step about attention teacher data which is said teacher data which is going to calculate a predicted value.

An arithmetic step which calculates said prediction coefficient based on two or more data extracted in said extraction step.

[Claim 24]A data processing device which processes input data characterized by comprising the followingand is provided with the 1st device that predicts output data to the input dataand the 2nd device that learns a prediction coefficient used for predicting said output data.

The 1st determination means that determines two or more data which extracts said 1st device from said input data based on the waveform characteristic of said input data.

The 1st extraction means that extracts two or more 1st data from said input data according to determination in said 1st determination means about attention output data which is said output data which is going to calculate a predicted value.

A creating means which generates student data which serves as a student from teacher data in which said 2nd device serves as a teacher for study of said prediction coefficient including a prediction means which calculates a predicted

value of said attention output data based on two or more 1st data extracted in said 1st extraction means.

The 2nd determination means that determines two or more data extracted from said student data based on the waveform characteristic of said student data. The 2nd extraction means that extracts two or more 2nd data from said student data according to determination in said 2nd determination means about attention teacher data which is said teacher data which is going to calculate a predicted value. A calculating means which calculates said prediction coefficient based on two or more data extracted in said 2nd extraction means.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the data processing device it enables it to raise the processing performance at the time of performing data processingsuch as image data, a data processing method and a medium concerning a data processing device, a data processing method and a medium.

[0002]

[Description of the Prior Art] This applicant has proposed class sorting adaptation processing previously, for example as processing for improving improvement and other picturesuch as image quality of a picture.

[0003] Class sorting adaptation processing consists of class sorting processing and adaptive processing and performs adaptive processing for data for every class part opium poppy and class by class sorting processing based on the character.

Adaptive processing is a thing of the following techniques.

[0004] By namely the thing for which the predicted value of the pixel of an original image is calculated by the linear combination of the pixel (suitably henceforth an input pixel) for which an inputted image (picture of the processing object of class sorting adaptation processing) is constituted from adaptive processing, for example and a predetermined prediction coefficient. The picture which removed the noise contained in the inputted image, the picture which has improved the dotage produced in the inputted image, the picture which raised resolution etc. are acquired.

[0005] While using as teacher data original images (for example the picture which does not contain a noise, a picture without dotage, a high-resolution picture etc.) now specifically, for example, the inputted image which superimposed the noise on the original image or added the shading off is used as student data. The predicted value $E[y]$ of the pixel value y of the pixel (suitably henceforth original picture matter) which constitutes an original image A set of pixel value x_1 of some input pixels (pixel which constitutes an inputted image) x_2 and ... It considers asking by the primary linearity coupled models specified by the linear combination of

predetermined prediction coefficient w_1, w_2 and ... In this case the predicted value $E[y]$ can be expressed with a following formula.

[0006]

$$E[y] = w_1 x_1 + w_2 x_2 + \dots \quad (1)$$

Procession Y' which becomes by the procession X which becomes by the procession W which becomes by set of the prediction coefficient and the student data aggregate in order to generalize a formula (1) and set of predicted value $E[y]$ [0007]

[Equation 1]

If a definition is come out and given the following observation equations will be materialized.

[0008]

$$XW = Y' \dots (2)$$

In [ingredient x_{ij} of the procession X means here the j -th student data in the student data aggregate (student data aggregate used for prediction of teacher data y_i of eye i affair) of eye i affair and] a formula (1) ingredient w_j of the procession W The prediction coefficient which a product with the j -th student data in the student data aggregate calculates is expressed. y_i expresses the teacher data of eye i affair therefore $E[y_i]$ expresses the predicted value of the teacher data of eye i affair.

[0009] And it considers applying a least square method to this observation equation and calculating the predicted value $E[y]$ near the pixel value y of original picture matter. In this case the procession E which becomes by set of the remainder e of predicted value $E[y]$ to the procession Y which becomes by set of the true pixel value (true value) y of the original picture matter used as teacher data and the pixel value y of original picture matter [0010]

[Equation 2]

If a definition is come out and given the following remainder equations will be materialized from an equation (2).

[0011]

$$XW = Y + E \dots (3)$$

In this case prediction coefficient w_i for calculating the predicted value $E[y]$ near the pixel value y of original picture matter is a square error. [0012]

[Equation 3]

It can ask by using the minimum.

[0013] Therefore when what differentiated the above-mentioned square error from prediction coefficient w_i is set to 0 in order that prediction coefficient w_i which fills a following formula may calculate the predicted value $E[y]$ near the pixel value y

of original picture matter it will call it an optimum value.

[0014]

[Equation 4]

... (4)

Then a following formula is first materialized by differentiating a formula (3) from prediction coefficient w_i .

[0015]

[Equation 5]

... (5)

A formula (6) is obtained from the formula (4) and (5).

[0016]

[Equation 6]

... (6)

If the student data x in the remainder equation of an equation (3) the prediction coefficient w teacher data y and the relation of the remainder e are taken into consideration the following normal equations can be obtained from an equation (6).

[0017]

[Equation 7]

... (7)

Each equation which constitutes the normal equation of an equation (7) is that only a certain amount of number prepares the student data x and teacher data y . The optimal prediction coefficient w can be calculated by being able to build only the same number as the number of the prediction coefficients w which should be calculated therefore solving a formula (7) (however in order to solve a formula (7) in a formula (7) the procession which comprises a coefficient concerning the prediction coefficient w needs to be Masanori). In solving a formula (7) it is possible to sweep out and touse law (elimination of Gauss-Jordan) etc. for example.

[0018] Adaptive processing calculates the optimal prediction coefficient w as mentioned above and calculates the predicted value $E[y]$ near the pixel value y of original picture matter by a formula (1) further using the prediction coefficient w .

[0019] Although adaptive processing is not included in an inputted image it is the point that the ingredient contained in an original image is reproduced and differs from mere interpolation processing for example. Namely in adaptive processing as long as a formula (1) is seen it is the same as that of the interpolation processing what is called using an interpolation filter but. Since [for which the prediction coefficient w equivalent to the tap coefficient of the interpolation filter uses

teacher data y] it asks by study so to speak the ingredient contained in an original image is reproducible. As adaptive processing can be called processing which so to speak has a creation (resolution imagination) operation of a picture and being mentioned above from this The predicted value of the original image which removed a noise and dotage from the inputted image is calculated and also when changing the picture of a low resolution or standard resolution into the picture of high resolution it can use for example.

[0020]

[Problem(s) to be Solved by the Invention] As mentioned above in class sorting adaptation processing adaptive processing is performed for every class but. Original picture matter which is going to calculate a predicted value in the class sorting performed in the preceding paragraph (original picture matter) Since it does not necessarily actually exist other than the time of study here It observes for being assuming two or more input pixels around the position of the noticed picture element are extracted and the class division of the noticed picture element is carried out based on the character (for example the pattern of the pixel value which are two or more of the input pixels the inclination of a pixel value etc.). And as two or more input pixels used for this class sorting it sees from a noticed picture element and the input pixel in a fixed position is extracted.

[0021] However in the case where an inputted image with dotage is changed into the picture which has improved the dotage by class sorting adaptation processing for example etc. Regardless of the degree of dotage of the inputted image it sees from a noticed picture element and if the input pixel in a fixed position was used for the class sorting of the noticed picture element class part [which fully reflected the character of the noticed picture element] being injured may become difficult.

[0022] That is when performing class sorting adaptation processing for an inputted image with the small degree of dotage (degree of dotage) for example it can see from a noticed picture element and the direction which performs class sorting using the input pixel in a comparatively near position can perform the class division which fully reflected the character of the noticed picture element. When performing class sorting adaptation processing for an inputted image with the large degree of dotage it can see from a noticed picture element and the direction which performs class sorting using the input pixel in a comparatively far position can perform the class division which fully reflected the character.

[0023] For example when the inputted image of the peripheral part of the position of a noticed picture element is flat the class division in which the direction which performs class sorting using the input pixel in the wide range of the inputted image in which a certain amount of change is seen fully reflected the character of the noticed picture element can be performed.

[0024] Therefore see from a noticed picture element and if the input pixel in a fixed position was used for the class sorting of the noticed picture element The picture which has fully improved the inputted image may not be acquired according to the thing which fully reflected the character of the noticed picture element and which

it cannot be injured by a class and the processing performance of class sorting adaptation processing deteriorates as a result. i.e. class sorting processing.

[0025] Although it sees from a noticed picture element and the linear prediction type of a formula (1) calculates and the predicted value which is a noticed picture element is calculated also by adaptive processing using the input pixel in a fixed position. It is expected that see from a noticed picture element and the small predicted value of a prediction error [as opposed to a noticed picture element in the direction which calculated the linear prediction type of the formula (1)] is calculated like the case in class sorting also in this case using the input pixel in a variable position if needed.

[0026] This invention is made in view of such a situation. For example, it enables it to raise processing performance such as class sorting adaptation processing.

[0027]

[Means for Solving the Problem] This invention is characterized by the 1st data processing device comprising the following.

A determination means to determine two or more data extracted from input data based on the waveform characteristic of input data.

An extraction means to extract two or more data from input data about attention output data which is output data which is going to calculate a predicted value according to determination in a determination means.

A prediction means which calculates a predicted value of attention output data based on two or more data extracted in an extraction means.

[0028] In the 1st data processing device based on two or more data extracted in an extraction means. A class sorting means to perform class sorting about attention output data and to output a corresponding class code can be formed further and a prediction means can be made to be asked for a predicted value of attention output data in this case using a predetermined prediction coefficient corresponding to a class code.

[0029] A prediction means can be made to linearity-primary-predict attention output data using a prediction coefficient. A prediction means can be made to linearity-primary-predict attention output data using a prediction coefficient and two or more data extracted in an extraction means.

[0030] A prediction coefficient memory measure which has memorized a prediction coefficient can be further provided in the 1st data processing device for every class code.

[0031] A determination means can be made to be able to detect an extremum of input data and two or more data extracted from input data can be made to determine it as it based on the detection result. A determination means can be made to be able to calculate a difference value of input data and two or more data extracted from input data can be made to determine it as it based on the result of an operation. A determination means can be made to be able to calculate an error of input data to a function which approximates input data and two or more data extracted from input data can be made to determine it as it based on the result of

an operation.

[0032]Input data and output data can be made into image data. An extraction means can be made to extract a pixel which exists on the outskirts spatially or in time from image data as input data to a pixel as attention output data in this case.

[0033]This invention is characterized by the 1st data processing method comprising the following.

A determination step which determines two or more data extracted from input data based on the waveform characteristic of input data.

An extraction step which extracts two or more data from input data about attention output data which is output data which is going to calculate a predicted value according to determination in a determination step.

A prediction step which calculates a predicted value of attention output data based on two or more data extracted in an extraction step.

[0034]This invention is characterized by a program which a computer is made to execute comprising the following in the 1st medium.

A determination step which determines two or more data extracted from input data based on the waveform characteristic of input data.

An extraction step which extracts two or more data from input data about attention output data which is output data which is going to calculate a predicted value according to determination in a determination step.

A prediction step which calculates a predicted value of attention output data based on two or more data extracted in an extraction step.

[0035]This invention is characterized by the 2nd data processing device comprising the following.

A creating means which generates student data which serves as a student from teacher data which serves as a teacher for study of a prediction coefficient.

A determination means to determine two or more data extracted from student data based on the waveform characteristic of student data.

An extraction means to extract two or more data from student data about attention teacher data which is teacher data which is going to calculate a predicted value according to determination in a determination means.

A calculating means which calculates a prediction coefficient based on two or more data extracted in an extraction means.

[0036]In the 2nd data processing devicebased on two or more data extracted in an extraction meansA class sorting means to perform class sorting about attention teacher dataand to output a corresponding class code can be formed furtherand a calculating means can be made to be asked for a prediction coefficient for every class code in this case using two or more data extracted in an extraction means.

[0037]A calculating means can be made to be asked for a prediction coefficient for teacher data to be obtained by linearity primary prediction. A calculating means can be made to be asked for a prediction coefficient for teacher data to be

obtained by linearity primary prediction using two or more data extracted in an extraction means.

[0038] A determination means can be made to be able to detect an extremum of student data and two or more data extracted from student data can be made to determine it as it based on the detection result. A determination means can be made to be able to calculate a difference value of student data and two or more data extracted from student data can be made to determine it as it based on the result of an operation. A determination means can be made to be able to calculate an error of student data to a function which approximates student data and two or more data extracted from student data can be made to determine it as it based on the result of an operation.

[0039] Student data and teacher data can be made into image data. In this case an extraction means can be made to extract a pixel which exists on the outskirts spatially or in time from image data as student data to a pixel as attention teacher data.

[0040] This invention is characterized by the 2nd data processing method comprising the following.

A generation step which generates student data which serves as a student from teacher data which serves as a teacher for study of a prediction coefficient.

A determination step which determines two or more data extracted from student data based on the waveform characteristic of student data.

An extraction step which extracts two or more data from student data about attention teacher data which is teacher data which is going to calculate a predicted value according to determination in a determination step.

An arithmetic step which calculates a prediction coefficient based on two or more data extracted in an extraction step.

[0041] This invention is characterized by a program which a computer is made to execute comprising the following in the 2nd medium.

A generation step which generates student data which serves as a student from teacher data which serves as a teacher for study of a prediction coefficient.

A determination step which determines two or more data extracted from student data based on the waveform characteristic of student data.

An extraction step which extracts two or more data from student data about attention teacher data which is teacher data which is going to calculate a predicted value according to determination in a determination step.

An arithmetic step which calculates a prediction coefficient based on two or more data extracted in an extraction step.

[0042] This invention is characterized by the 3rd data processing device comprising the following.

The 1st determination means that determines two or more data extracted from input data based on the waveform characteristic of input data.

The 1st extraction means that extracts two or more 1st data from input data

about attention output data which is output data which is going to calculate a predicted value according to determination in the 1st determination means.
 A prediction means which calculates a predicted value of attention output data based on two or more 1st data extracted in the 1st extraction means.
 A creating means which generates student data which serves as a student from teacher data which serves as a teacher for study of a prediction coefficient
 The 2nd determination means that determines two or more data extracted from student data based on the waveform characteristic of student data
 A calculating means which calculates a prediction coefficient about attention teacher data which is teacher data which is going to calculate a predicted value based on two or more data extracted in the 2nd extraction means that extracts two or more 2nd data from student data and the 2nd extraction means according to determination in the 2nd determination means.

[0043] In the 1st data processing device of this invention, a data processing method and a medium. Based on the waveform characteristic of input data, two or more data extracted from input data is determined, and two or more data is extracted from input data about attention output data which is output data which is going to calculate a predicted value according to the determination. And a predicted value of attention output data is calculated based on two or more of the extracted data.

[0044] In the 2nd data processing device of this invention, a data processing method and a medium. Student data which serves as a student is generated from teacher data which serves as a teacher for study of a prediction coefficient, and two or more data extracted from student data is determined based on the waveform characteristic of the student data. And about attention teacher data which is teacher data which is going to calculate a predicted value according to the determination, two or more data is extracted from student data, and a prediction coefficient is calculated based on two or more of the extracted data.

[0045] In the 3rd data processing device of this invention, based on the waveform characteristic of input data, two or more data extracted from input data is determined, and two or more 1st data is extracted from input data about attention output data which is output data which is going to calculate a predicted value according to the determination. And a predicted value of attention output data is calculated based on two or more of the 1st extracted data. On the other hand, student data which serves as a student is generated from teacher data which serves as a teacher for study of a prediction coefficient, and two or more data extracted from student data is determined based on the waveform characteristic of the student data. And about attention teacher data which is teacher data which is going to calculate a predicted value according to the determination, two or more 2nd data is extracted from student data, and a prediction coefficient is calculated based on two or more of the extracted data.

[0046]

[Embodiment of the Invention] Drawing 1 shows the example of composition of the

1 embodiment of the image processing device which applied this invention.

[0047] In this image processing device if SD (Standard Density) picture with low resolution is inputted as an inputted image for example by performing class sorting adaptation processing to that inputted image The picture (HD (High Density) picture) of high resolution is outputted.

[0048] Namely this image processing device comprises frame memory 1 class tap generating circuit 2 prediction tap generating circuit 3 class sorting circuit 4 and coefficient RAM (Random Access Memory) 5 the prediction arithmetic circuit 6 and the tap determining circuit 7 and there The inputted image (SD picture) used as the object which improves resolution is inputted.

[0049] The frame memory 1 is made as [store / for example / the inputted image inputted into an image processing device / temporarily / per frame]. At this embodiment the frame memory 1 can perform the processing in real time even if the inputted image which can memorize the inputted image of a multiple frame now with a bank change and is inputted into an image processing device by this is an animation.

[0050] Original picture matter which the class tap generating circuit 2 tends to ask for a predicted value by class sorting adaptation processing (here) The input pixel which uses the pixel of a high-resolution HD image for the class sorting about the noticed picture element as a noticed picture element According to the tap information from the tap determining circuit 7 it extracts from the inputted image memorized by the frame memory 1 and this is outputted to the class sorting circuit 4 as a class tap.

[0051] The input pixel used for the prediction tap generating circuit 3 calculating the predicted value of a noticed picture element in the prediction arithmetic circuit 6 According to the tap information from the tap determining circuit 7 it extracts from the inputted image memorized by the frame memory 1 and is made as [supply / the prediction arithmetic circuit 6] by making this into a prediction tap.

[0052] Based on the class tap from the class tap generating circuit 2 the class sorting circuit 4 carries out class sorting of the noticed picture element and is made as [give / to coefficient RAM 5 / the class code corresponding to the class obtained as a result / as an address]. Namely the class sorting circuit 4 the class tap from the class tap generating circuit 2 For example 1-bit ADRC (Adaptive Dynamic Range Coding) processing is carried out and the ADRC code obtained as a result is outputted to coefficient RAM 5 as a class code.

[0053] In K bit ADRC processing the maximum MAX and the minimum MIN of a pixel value of an input pixel which constitute a class tap are detected here for example $DR = MAX - MIN$ is used as the local dynamic range of a set and re quantization of the input pixel which constitutes a class tap is carried out to K bit based on this dynamic range DR. That is out of the pixel value of the pixel which constitutes a class tap the minimum MIN is subtracted and division (quantization) of the subtraction value is done by $DR/2^K$. Therefore when 1-bit ADRC processing of the class tap is carried out the pixel value of each input pixel which constitutes

the class tap will be 1 bit. And the bit string which put in order the pixel value of 1 bit about each pixel which constitutes a class tap acquired by making it above in this case in predetermined order is outputted as an ADRC code.

[0054] If coefficient RAM5 has memorized the prediction coefficient for every class obtained by performing study in the learning device mentioned later and a class code is supplied from the class sorting circuit 4, the prediction coefficient memorized to the address corresponding to the class code is read and the prediction arithmetic circuit 6 is supplied.

[0055] The prediction coefficient w about the class of a noticed picture element to which the prediction arithmetic circuit 6 is supplied from coefficient RAM5, and ... By performing the operation shown in the formula (1) using prediction tap (pixel value of each pixel to constitute) x_1 from the prediction tap generating circuit 3, and ... the predicted value $E[y]$ of the noticed picture element y is calculated and this is outputted as a pixel value of the pixel which has improved resolution.

[0056] Based on the waveform characteristic of the inputted image memorized by the frame memory 1, the tap determining circuit 7, the input pixel which makes a class tap and a prediction tap constitute is determined and the information (suitably henceforth tap information) about the input pixel which makes the class tap and prediction tap constitute is supplied to the class tap generating circuit 2 and the prediction tap generating circuit 3.

[0057] That is, the tap determining circuit 7 is a central pixel (here) about the input pixel in the position of a noticed picture element, for example, as a dotted line surrounds and shows to drawing 2. For example, square-like the class tap and prediction tap which horizontal x length becomes at 5×5 pixels as meaning the pixel in the position of the center of gravity, for example. It assumes as a fundamental tap (suitably henceforth a basic tap) which makes a class tap generating circuit and the prediction tap generating circuit 3 constitute (both are summarized and it is only hereafter called a tap suitably).

[0058] Herein drawing 2 seal shows the pixel (HD picture element) which constitutes an HD image and O seal shows the pixel (SD pixel) which constitutes SD picture as an inputted image. Therefore in drawing 2 SD picture is what set the pixel number of the side of an HD image and each length to one half.

[0059] If a basic tap is assumed, the tap determining circuit 7 will detect the direction which passes along other SD pixels (input pixel) of a basic tap by making the central pixel into the starting point, for example, as shown in drawing 3. Here, as a basic tap is mentioned above when it comprises 5×5 pixels as shown in drawing 3, direction D_1 of 16 thru/or D_{16} which makes a central pixel the starting point will be detected.

[0060] The tap determining circuit 7 determines SD pixel which makes a tap constitute eventually based on the waveform characteristic (characteristic of a pixel value) of SD pixel which exists in the direction about D for all directions i (here $i = 12 \dots 16$). That is, about D for all directions i based on the waveform characteristic of SD picture which exists in the direction as shown in drawing 4, the

position of SD pixel which constitutes the tap which exists in the direction is moved. And the tap determining circuit 7 supplies the information about the position of SD pixel which will constitute a tap eventually as tap information to the class tap generating circuit 2 and the prediction tap generating circuit 3 as a result of the movement.

[0061]Next with reference to the flow chart of drawing 5 the resolution improvement processing performed in the image processing device of drawing 1 in which the resolution of an inputted image is improved is explained.

[0062]To the frame memory 1 SD picture (video) which is an object of resolution improvement processing is supplied one by one per frame as an inputted image and the inputted image supplied per frame such is memorized one by one in the frame memory 1.

[0063]And the predetermined HD picture element which is going to calculate a predicted value is made into a noticed picture element and in Step S1 the tap determining circuit 7 Based on the waveform characteristic of the inputted image memorized by the frame memory 1 the input pixel which makes the tap about a noticed picture element constitute is determined and the tap information about the position of the input pixel is outputted to the class tap generating circuit 2 and the prediction tap generating circuit 3.

[0064]The class tap generating circuit 2 or the prediction tap generating circuit 3 In [if tap information is received from the tap determining circuit 7] Step S2 According to the tap information the input pixel which makes the class tap or prediction tap about a noticed picture element which is going to calculate a predicted value constitute is read from the frame memory 1 and this constitutes a class tap or a prediction tap respectively. This class tap or prediction tap is supplied to the class sorting circuit 4 or the prediction arithmetic circuit 6 respectively.

[0065]If a class tap is received from the class tap generating circuit 2 in Step S3 based on the class tap the class sorting circuit 4 will perform class sorting and will output as an address the class code obtained as a result to coefficient RAM5 about a noticed picture element. In step S4 coefficient RAM5 reads the prediction coefficient memorized to the address corresponding to the class code from the class sorting circuit 4 and it supplies it to the prediction arithmetic circuit 6.

[0066]In Step S5 by performing the operation of the linear prediction type showing in a formula (1) using the prediction tap from the prediction tap generating circuit 3 and the prediction coefficient from coefficient RAM5 the predicted value $E[y]$ of the noticed picture element (HD picture element) y is calculated and it progresses to Step S6 in the prediction arithmetic circuit 6. In Step S6 the prediction coefficient arithmetic circuit 6 outputs the predicted value $E[y]$ of the noticed picture element y for which it asked at Step S5 as an HD picture element which has improved resolution and it progresses to Step S7.

[0067]It is judged whether the predicted value of all the HD picture elements which constitute the frame of a noticed picture element from Step S7 was calculated. When judged with not having asked yet it returns to Step S1 and the

processing after Step S1 is newly repeated as a noticed picture element in the HD picture element which has not been asked for a predicted value yet.

[0068]When judged with the predicted value of all the HD picture elements which constitute the frame of a noticed picture element having been calculated in Step S7, it progresses to Step S8 and it is judged whether the inputted image (SD picture) corresponding to the frame of the HD image which should be processed next is memorized by the frame memory 1. In Step S8, the inputted image corresponding to the frame of the HD image which should be processed next is judged with the frame memory 1, memorizing in the predetermined HD picture element of the frame of the HD image which should be processed to the next as a noticed picture element, it returns to Step S1 and the same processing is newly repeated hereafter.

[0069]On the other hand, in Step S8, when the inputted image corresponding to the frame of the HD image which should be processed next is judged as the frame memory 1 not memorizing, resolution improvement processing is ended.

[0070]Next, with reference to the flow chart of drawing 6a, 1st embodiment of the tap decision processing in Step S1 of drawing 5 performed in the tap determining circuit 7 is described.

[0071]It is hereafter called a tap suitably one by one [its / pixel] besides the whole set of SD pixel used for the operation of class sorting and the linear prediction type of a formula (1).

[0072]In the tap determining circuit 7a, a basic tap is set up in Step S11. Namely, in Step S11, as the dotted line surrounded and showed to drawing 2, the tap which horizontal x length becomes at 5x5 pixels is set up as a basic tap by making the input pixel in the position of a noticed picture element into a central pixel.

[0073]And it progresses to Step S12, and as shown in drawing 3, direction D_1 of 16 thru/or D_{16} which passes along other SD pixels of a basic tap is detected by making a central pixel into the starting point, and it progresses to Step S13.

[0074]The variable i which expresses with Step S13 direction D_1 of 16 thru/or D_{16} detected at Step S12 is initialized by 1, for example, and progresses to Step S14, and the variable j showing the tap on D for all directions i is initialized by 1, for example, and progresses to Step S15.

[0075]In Step S15, it is judged whether SD pixel (pixel value) which is tap $T_{i \text{ in the } j\text{-th and } j}$ from the central pixel on direction D_i serves as an extremum. When judged with SD pixel used as tap $T_{i \text{ and } j}$ not serving as an extremum in Step S15, progress to Step S16 and Tap $T_{i \text{ on direction } D_i \text{ and } j}$. The tap outside it (direction which is not a central pixel side) is moved to the position which separated only 1 pixel from the central pixel, for example. And it returns to Step S15 and the same processing is repeated hereafter.

[0076]In Step S15, when judged with SD pixel used as tap $T_{i \text{ and } j}$ serving as an extremum, it progresses to Step S17, and it *****s only 1, and the variable j progresses to Step S18. It is judged whether it is below pixel number J_i which constitutes taps other than a central pixel which have the variable j on direction D_i from Step S18.

[0077] Herefor example in drawing 3 direction $D_1 D_3 D_5 \dots J_i$ about D_{15} are 2 and direction $D_2 D_4 D_6 \dots J_i$ about D_{16} are 1.

[0078] When judged with it being below pixel number J_i which constitutes taps other than a central pixel which have the variable j on direction D_i in Step S18 That is when all the SD pixels that constitute taps other than a central pixel on direction D_i have not been supposed that the extremum is taken yet it returns to Step S15 and the same processing is repeated for tap T_i in the position of SD pixel which is not the extremum and j .

[0079]. In Step S18 the variable j is on direction D_i . When judged with it not being below pixel number J_i which constitutes taps other than a central pixel (i.e. when all the SD pixels that constitute taps other than a central pixel on direction D_i are presupposed that the extremum is taken) it progresses to Step S19 and *****s the variable i only for 1. And it progresses to Step S20 and it is judged whether the variable i is below the total I of the direction detected at Step S12 (the embodiment of drawing 3 16).

[0080] In Step S20 when judged with the variable i being below I (i.e. when SD pixel used as an extremum is used as the tap yet about no directions detected at Step S12) it returns to Step S14 and the same processing is repeated hereafter.

[0081] When it is judged with the variable i not being below I in Step S20 on the other hand Namely when SD pixel used as an extremum is used as a tap about all the directions detected at Step S12 progress to Step S21 and the information about the position of SD pixel which constitutes the tap now as tap information It is outputted to the class tap generating circuit 2 and the prediction tap generating circuit 3 and a return is carried out.

[0082] According to a 1st embodiment of the above tap decision processings in the class tap generating circuit 2 and the prediction tap generating circuit 3 a tap as shown in drawing 7 will be constituted.

[0083] That is drawing 7 (also setting to drawing 9 and drawing 11 which are mentioned later the same) shows SD pixel in the direction D_1 and direction D_9 opposite to it 180 degrees for example paying attention to direction D_1 of the directions of 16 shown in drawing 3.

[0084] In drawing 7 (also setting to drawing 9 and drawing 11 the same). While expressing with n the position of the central pixel which constitutes a tap and expressing with $n-m$ further the position of the pixel which only m pixel (m is a positive integer) has in the direction of D_1 from the position n the position of the pixel which only m pixel has in the direction of D_9 from the position n is expressed with $n+m$.

[0085] In drawing 7 (also setting to drawing 9 and drawing 11 the same) x seal shows SD pixel (pixel value) and O seal shows the tap (SD pixel which has become).

[0086] Two SD pixels by which two SD pixels which adjoin in the direction about direction D_1 adjoin in the direction also about direction D_9 again serve as a tap to SD pixel which drawing 7 (A) shows the basic tap therefore is a central pixel.

[0087] Drawing 7 (B) to SD pixel which shows the tap constituted by the tap decision processing of drawing 6 and is a central pixel from the basic tap of drawing 7 (A) about direction D_1 . SD pixel which SD pixel used as the maximal value which

appears first in accordance with the direction and SD pixel used as the minimal value serve as a tap and serves as the minimal value first expressed in accordance with the direction also about direction D_9 and SD pixel used as the maximal value serve as a tap.

[0088] Next with reference to the flow chart of drawing 8a 2nd embodiment of the tap decision processing in Step S1 of drawing 5 performed in the tap determining circuit 7 is described.

[0089] In Step S31 or S32 in the tap determining circuit 7 the respectively same processing as the case in Step S11 or S12 of drawing 6 is performed and by this Detection of direction D_1 of 16 thru/or D_{16} which passes along SD pixel of setting out of a basic tap and everything but the basic tap which makes a central pixel the starting point is performed.

[0090] And progress to Step S33 and like the case in Step S13 of drawing 6 The variable i showing the direction detected at Step S32 is initialized by 1 for example and progresses to Step S34 and dynamic range DR_i of SD pixel used as the tap on direction D_i calculates. That is in Step S34 the maximum and the minimum (the greatest pixel value and the minimum pixel value) are detected out of all (a central pixel is included) SD pixels used as the tap on direction D_i and the difference of the maximum and minimum is called for as dynamic range DR_i .

[0091] After calculation of dynamic range DR_i it progresses to Step S35 and it is judged from the threshold th to which the dynamic range DR_i was set beforehand whether it is size. When judged with dynamic range DR_i being below the threshold th in Step S35 among SD pixels used as the tap on direction D_i When there is no so big change therefore stationarity is observed in the tap on direction D_i it progresses to Step S36 and SD pixel which constitutes a tap excluding a central pixel is changed so that the interval of the taps on direction D_i may spread by 1 pixel for example. And it progresses to Step S34 and the same processing is repeated hereafter.

[0092] Among SD pixels which serve as a tap on direction D_i when judged with dynamic range DR_i being size from the threshold th in Step S35 When it is admitted that there is a comparatively big change therefore there is no stationarity in the tap on direction D_i it progresses to Step S37 and ***** the variable i only 1. And it progresses to Step S38 and it is judged whether the variable i is below the total I of the direction detected at Step S32.

[0093] When judged with the variable i being below I in Step S38 That is about all the directions detected at Step S32 when SD pixel which a dynamic range consists large of from the threshold th has not been used as the tap yet it returns to Step S34 and the same processing is repeated hereafter.

[0094] When it is judged with the variable i not being below I in Step S38 on the other hand Namely when SD pixel which a dynamic range consists large of from the threshold th is used as a tap about all the directions detected at Step S32 It progresses to Step S39 and now as tap information the information about the position of SD pixel which constitutes the tap is outputted to the class tap generating circuit 2 and the prediction tap generating circuit 3 and carries out a

return.

[0095] According to a 2nd embodiment of the above tap decision processing in the class tap generating circuit 2 and the prediction tap generating circuit 3 a tap as shown in drawing 9 will be constituted.

[0096] Namely drawing 9 (A) to SD pixel which shows the basic tap therefore is a central pixel like drawing 7 (A) about direction D_1 . Two SD pixels by which two SD pixels which adjoin in the direction adjoin in the direction also about direction D_9 again serve as a tap.

[0097] Drawing 9 (B) is shown from the basic tap of drawing 9 (A) and the tap constituted by the tap decision processing of drawing 8 about both direction D_1 and D_9 . SD pixel which makes dynamic range DR_1 and DR_9 larger than the threshold th serves as a tap.

[0098] In the embodiment of drawing 8 and drawing 9 extended the interval of SD pixels used as a tap so that dynamic range DR_i which is the difference of the maximum of the SD pixels used as the tap on direction D_i and the minimum might become large from the threshold th but. In addition it is possible to extend the interval of SD pixels used as a tap etc. so that the difference of what SD pixel which serves as a tap on direction D_i for example adjoins may become large from the threshold th .

[0099] Next with reference to the flow chart of drawing 10a 3rd embodiment of the tap decision processing in Step S1 of drawing 5 performed in the tap determining circuit 7 is described.

[0100] In the tap determining circuit 7 the respectively same processing as the case in Steps S11 thru/or S13 of drawing 6 is performed in Steps S41 thru/or S43. Thereby detection of direction D_1 of 16 which passes along other SD pixels of the basic tap which makes the starting point setting out of a basic tap and a central pixel thru/or D_{16} and initialization showing the detected direction of the variable i are performed.

[0101] And it progresses to Step S44 and for example straight-line (suitably henceforth approximation straight lines) L_i as a function which approximates SD pixel (pixel value) used as the basic tap on direction D_i is called for and it progresses to Step S45. SD pixel (a central pixel is included) which serves as a tap on direction D_i in Step S45 -- the error (for example square error) over each approximation-straight-lines L_i is searched for and the integrated value of the error is calculated further. And it progresses to Step S46 and it is judged whether the integrated value of the error is size from a predetermined threshold.

[0102] When it judges that an integrated value with error is not size from a predetermined threshold in Step S46 among SD pixels used as the tap on direction D_i When there is no so big change and stationarity is accepted it progresses to Step S47 and all taps other than a central pixel on direction D_i are moved by 1 pixel along with the direction D_i (on outside). And it progresses to Step S45 and the same processing is repeated hereafter.

[0103] Among SD pixels which serve as a tap on direction D_i when judged with an integrated value with error being size from a predetermined threshold in Step

S46 When there is a comparatively big change and stationarity is not accepted it progresses to Step S48 and *****s the variable i only 1. And it progresses to Step S49 and it is judged whether the variable i is below the total I of the direction detected at Step S42.

[0104] In Step S49 when judged with the variable i being below I namely when SD pixel which an integrated value with error consists large of from a predetermined threshold is used as the tap yet about no directions detected at Step S42 it returns to Step S44 and the same processing is repeated hereafter.

[0105] When it is judged with the variable i not being below I in Step S49 on the other hand namely when SD pixel which an integrated value with error consists large of from a predetermined threshold about all the directions detected at Step S42 is used as a tap it progresses to Step S50 and as tap information the information about the position of SD pixel which constitutes the tap now is outputted to the class tap generating circuit 2 and the prediction tap generating circuit 3 and carries out a return.

[0106] According to a 3rd embodiment of the above tap decision processing in the class tap generating circuit 2 and the prediction tap generating circuit 3 a tap as shown in drawing 11 will be constituted.

[0107] Namely drawing 11 (A) to SD pixel which shows the basic tap therefore is a central pixel like drawing 7 (A) about direction D_1 . Two SD pixels by which two SD pixels which adjoin in the direction adjoin in the direction also about direction D_9 again serve as a tap.

[0108] Drawing 11 (B) is shown from the basic tap of drawing 11 (A) and the tap constituted by the tap decision processing of drawing 10 about both direction D_1 and D_9 . SD pixel which makes the integrated value of the error over approximation-straight-lines L_1 and L_9 larger than a predetermined threshold serves as a tap.

[0109] Although SD pixel to straight-line L_1 which approximates SD pixel used as a basic tap on direction D_1 which makes a tap constitute based on the integrated value of the error of SD pixel which constitutes a tap was determined in the embodiment of drawing 10 and drawing 11 In addition it is also possible to determine SD pixel which makes a tap constitute for example based on distribution with error etc.

[0110] Although all taps other than a central pixel on direction D_1 were moved by 1 pixel along with the direction D_1 in Step S47 in the embodiment of drawing 10 It may be made to move a tap in addition to this in Step S47 for example so that the interval of the taps on direction D_1 may be extended for example by 1 pixel.

[0111] Although it asks for a straight line and the tap was determined in the embodiment of drawing 10 and drawing 11 based on the error over the straight line as a function which approximates SD pixel used as a basic tap on direction D_1 In addition it is also possible to search for the flat surface and curved surface which are a function which approximates SD pixel used as a basic tap which exists in the two or more directions for example and to determine a tap based on the error over the flat surface and curved surface.

[0112]Next drawing 12 shows the example of composition of the 1 embodiment of the learning device which calculates the prediction coefficient for every [coefficient RAM5 of drawing 1 is made to memorize] class.

[0113]The original image (HD image high-resolution here) used as teacher data y is supplied to the frame memory 61 per frame for example and the frame memory 61 stores the original image temporarily at it. The infanticide circuit 62 generates SD picture with low resolution as student data by reading the original image set to teacher data y in the study of a prediction coefficient memorized by the frame memory 61 and thinning out the pixel number which constitutes the original image. The seal 3 and the infanticide circuit 62 generate SD pixel similarly shown in drawing 2 by O seal by for example thinning out the pixel number of the width and length of an HD image shown in drawing 2 by x seal to one half respectively. This SD picture is supplied to the frame memory 63.

[0114]The frame memory 63 stores temporarily SD picture from the infanticide circuit 62. The frame memories 61 and 63 are constituted like the frame memory 1 of drawing 1.

[0115]The class tap generating circuit 64 or the prediction tap generating circuit 65 SD pixel which constitutes SD picture memorized by the frame memory 63 is used Like the class tap generating circuit 2 of drawing 1 or the prediction tap generating circuit 3 According to the tap information from the tap determining circuit 72 about the teacher data used as a noticed picture element a class tap or a prediction tap is constituted and the class sorting circuit 66 or the adder circuit 67 is supplied respectively. A prediction tap is supplied also to the adder circuit 67.

[0116]The class sorting circuit 66 is constituted like the class sorting circuit 4 of drawing 1 Based on the class tap from the class tap generating circuit 64 class sorting of the noticed picture element is carried out and a corresponding class code is given as an address to the prediction tap memory 68 and the teacher data memory 70.

[0117]The adder circuit 67 reads the memory value of the address corresponding to the class code which the class sorting circuit 66 outputs from the prediction tap memory 68 and The memory value The operation equivalent to the summation (σ) which serves as a multiplier of the prediction coefficient w in the left side of the normal equation of an equation (7) by adding SD pixel (pixel value) which constitutes the prediction tap from the prediction tap generating circuit 65 is performed. And the adder circuit 67 is made to memorize in the form which overwrites the result of an operation to the address corresponding to the class code which the class sorting circuit 66 outputs.

[0118]The prediction tap memory 68 memorizes the output value of the adder circuit 67 to the address while it reads the memory value of the address corresponding to the class which the class sorting circuit 66 outputs and supplies it to the adder circuit 67.

[0119]While reading the noticed picture element of the original picture matter which constitutes the original image memorized by the frame memory 61 as teacher data y the adder circuit 69 By adding teacher data (original picture matter)

y which read the memory value of the address corresponding to the class code which the class sorting circuit 66 outputs from the teacher data memory 70 and read it from the memory value and the frame memory 61. The operation equivalent to the summation (σ) in the right-hand side of the normal equation of an equation (7) is performed. And the adder circuit 69 is made to memorize in the form which overwrites the result of an operation to the address corresponding to the class code which the class sorting circuit 66 outputs.

[0120] The multiplication in a formula (7) is also performed in the adder circuits 67 and 69. That is in the adding machine 67 the multiplication of the SD pixel x and teacher data y which the multiplication of SD pixel x which constitute a prediction tap is also performed and constitute a prediction tap from the adding machine 69 is also performed. Therefore although the SD pixel x which constitutes a prediction tap is needed in the adding machine 69 this is supplied from the prediction tap generating circuit 65 as mentioned above.

[0121] The teacher data memory 70 memorizes the output value of the adder circuit 69 to the address while it reads the memory value of the address corresponding to the class code which the class sorting circuit 66 outputs and supplies it to the adder circuit 69.

[0122] the arithmetic circuit 71 -- the prediction tap memory 68 or the teacher data memory 70 -- from each. The prediction coefficient for every class is calculated by reading the memory value memorized to the address corresponding to each class code one by one building the normal equation showing in an equation (7) and solving this. namely the arithmetic circuit 71 -- the prediction tap memory 68 or the teacher data memory 70 -- the prediction coefficient for every class is calculated by building the normal equation of an equation (7) and solving this from the memory value memorized to the address corresponding to each class code of each.

[0123] The tap determining circuit 72 is performing the same tap decision processing as the tap determining circuit 7 of drawing 1. The tap information about the tap which the class tap generating circuit 64 and the prediction tap generating circuit 65 are made to generate is determined and the class tap generating circuit 64 and the prediction tap generating circuit 65 are supplied.

[0124] Next with reference to the flow chart of drawing 13 the learning processing which is performed in the learning device of drawing 12 and which calculates the prediction coefficient for every class is explained.

[0125] The HD image as an original image (video) used as teacher data is supplied to a learning device per frame and the HD image is memorized one by one in the frame memory 61. And in Step S61 the HD image as an original image memorized by the frame memory 61 is supplied to the infanticide circuit 62 and let it be SD picture there. As student data from the infanticide circuit 62 this SD picture is supplied to the frame memory 63 and is memorized.

[0126] And in [the tap determining circuit 72 makes the predetermined HD picture element of the frame of the HD image corresponding to the frame of SD picture memorized by the frame memory 63 a noticed picture element and] Step S62 SD

pixel which makes the tap about the noticed picture element constitute is determined like the case in the tap determining circuit 7 of drawing 1 and the tap information about the SD pixel is outputted to the class tap generating circuit 64 and the prediction tap generating circuit 65.

[0127] In the class tap generating circuit 64 or the prediction tap generating circuit 65. In Step S63 according to the tap information from the tap determining circuit 72 SD pixel which makes the class tap or prediction tap about a noticed picture element constitute is read from the frame memory 63 and a class tap or a prediction tap is constituted respectively. And a class tap is supplied to the class sorting circuit 66 and a prediction tap is supplied to the adder circuits 67 and 69.

[0128] In the class sorting circuit 66 it is made to be the same as that of the case in the class sorting circuit 4 of drawing 1 in Step S64 Class sorting of the noticed picture element is carried out using the class tap from the class tap generating circuit 64 and the class code as the class sorting result is given as an address to the prediction tap memory 68 and the teacher data memory 70.

[0129] And it progresses to Step S65 and an add lump of a prediction tap (student data) and teacher data is performed.

[0130] Namely in Step S65 the prediction tap memory 68 reads the memory value of the address corresponding to the class code which the class sorting circuit 66 outputs and supplies it to the adder circuit 67. The adder circuit 67 performs the operation equivalent to the summation (σ) used as the multiplier of the prediction coefficient in the left side of the normal equation of an equation (7) using the memory value supplied from the prediction tap memory 68 and SD pixel which constitutes a supplying—from prediction tap generating circuit 65 prediction tap. And the adder circuit 67 is made to memorize in the form which overwrites the result of an operation to the address of the prediction tap memory 68 corresponding to the class code which the class sorting circuit 66 outputs.

[0131] In Step S65 the teacher data memory 70 reads the memory value of the address corresponding to the class code which the class sorting circuit 66 outputs and supplies it to the adder circuit 69. From the frame memory 61 the adder circuit 69 reads a noticed picture element and performs the operation equivalent to the summation (σ) in the right-hand side of the normal equation of an equation (7) using the HD picture element used as the read noticed picture element and a prediction tap and the memory value supplied from the teacher data memory 70. And the adder circuit 69 is made to memorize in the form which overwrites the result of an operation to the address of the teacher data memory 70 corresponding to the class code which the class sorting circuit 66 outputs.

[0132] Then all the HD picture elements which progress to Step S66 and constitute the frame of a noticed picture element When it is judged whether it processed as a noticed picture element and it is judged with not having carried out yet it returns to Step S62 and the same processing is newly hereafter repeated as a noticed picture element in the HD picture element which has not been made into the noticed picture element yet.

[0133] In Step S66 it is judged whether the frame of the HD image which should

progress to Step S67 and then should process all the HD picture elements which constitute the frame of a noticed picture element when judged with having processed as a noticed picture element is memorized by the frame memory 61. In Step S67 when the frame of the HD image which should be processed next is judged as the frame memory 61 memorizing it returns to Step S61 and the same processing is repeated for the frame of the HD image which should be processed to the next.

[0134] The frame of the HD image which should be processed next in Step S67 When judged with the frame memory 61 not memorizing namely when it processes using all the HD images beforehand prepared for study progressing to Step S68 -- the arithmetic circuit 71 -- the prediction tap memory 68 or the teacher data memory 70 -- from each. The prediction coefficient for every class is calculated by reading the memory value memorized to the address corresponding to each class code one by one building the normal equation showing in an equation (7) and solving this. In Step S69 the arithmetic circuit 71 outputs the prediction coefficient for the every class for which it asked and ends learning processing.

[0135] In the learning processing of the above prediction coefficients although the class from which a number required to calculate a prediction coefficient of normal equations are not obtained may arise about such a class it is able to make it to output a default prediction coefficient for example etc.

[0136] As mentioned above since SD pixel which makes the tap constitute was determined based on the waveform characteristic of SD pixel which constitutes a tap For example the composition of the class tap for performing the class division which fully reflected the character of the noticed picture element and the prediction tap which makes the prediction error of a predicted value small can be attained and as a result the processing performance of class sorting adaptation processing can be raised.

[0137] Next hardware can also perform a series of processings mentioned above and software can also perform. When software performs a series of processings The program which constitutes the software is installed in the computer built into the pixel processing unit and learning device as hardware for exclusive use or the general-purpose computer which performs various kinds of processings by installing various kinds of programs.

[0138] Then the medium used in order to install in a computer the program which performs a series of processings mentioned above and to change it into the state which can be performed by computer with reference to drawing 14 is explained.

[0139] As shown in drawing 14 (A) a user can be provided with a program in the state where it installed in the hard disk 102 and the semiconductor memory 103 as a recording medium which are built in the computer 101 beforehand.

[0140] Or as shown in drawing 14 (B) again a program The floppy disk 111 CD-ROM (Compact.) To recording mediasuch as Disc Read Only Memory 112 the MO (Magneto optical) disk 113 DVD (Digital Versatile Disc) 114 the magnetic disk 115 and the semiconductor memory 116. It can store temporarily or permanently and can

provide as a software package.

[0141]Via [as a program is shown in drawing 14 (C)] the artificial satellite 122 for the digital satellite broadcasting from the download site 121In [transmit to the computer 101 on radio or transmit to the computer 123 with a cable via the networks 131such as LAN (Local Area Network) and the Internetand] the computer 101It can be made to store in the hard disk 102 etc. to build in.

[0142]The medium in this specification means the concept of a broad sense containing all these media.

[0143]The step which describes the program provided by a medium in this specificationIt is not necessary to necessarily process to a time series in accordance with the order indicated as a flow chartand a parallel target or the processing (for exampleparallel processing or processing by an object) performed individually is also included.

[0144]Nextdrawing 15 shows the example of composition of the computer 101 of drawing 14.

[0145]The computer 101 contains CPU(Central Processing Unit) 142as shown in drawing 15. Via the bus 141the input/output interface 145 is connected to CPU142 and CPU142If instructions are inputted when the input part 147 which comprises a keyboarda mouseetc. is operated by the user via the input/output interface 145According to itthe program stored in ROM(Read Only Memory) 143 corresponding to the semiconductor memory 103 of drawing 14 (A) is executed. Or a program by which CPU142 is stored in the hard disk 102A program which was transmitted from the satellite 122 or the network 131was received in the communications department 148and was installed on the hard disk 102Or the program which was read from the floppy disk 111 with which the drive 149 was equippedCD-ROM112MO disk 113DVD114or the magnetic disk 115and was installed on the hard disk 102It loads to RAM(Random Access Memory) 144and performs. And CPU142 outputs the processing result to the indicator 146 which comprises LCD (Liquid CryStal Display) etc. via the input/output interface 145 if neededfor example.

[0146]By linearity primary prediction class sorting application processing performs study which calculates a prediction coefficient for every class using teacher data and student dataand using the prediction coefficient and input data. Since the predicted value of teacher data is calculatedit becomes possible from input data to obtain the prediction coefficient for calculating a desired predicted value with the teacher data and student data which are used for study. That iswhile using a picture without dotage as teacher data for examplethe prediction coefficient which improves dotage can be obtained by using the picture which added dotage to the picture as student data. While using the picture which does not contain a noise as teacher data for examplethe prediction coefficient which removes a noise can be obtained by using the picture which added the noise to the picture as student data. Thereforethis invention can be appliedwhen improving dotagewhen [other] performing waveform equalizationfor exampleand when [when removing a noise besides in the case of raising resolution which was mentioned above or].

[0147]In this embodiment although video was set as the object of class sorting application processing it is possible to be further aimed at a still picture a sound the signal (RF (RadioFrequency) signal) reproduced from the recording medium besides video etc.

[0148]In this embodiment although a class tap and a prediction tap will be constituted from being constituted according to the same tap information by the same pixel it is possible to have different composition from a class tap and a prediction tap i.e. also constitute according to different tap information.

[0149]Although both a class tap and a prediction tap are seen from a noticed picture element and SD pixel of the variable position constituted it from this embodiment according to tap information it sees from a noticed picture element and either a class tap or the prediction taps can be constituted from an SD pixel of a fixed position.

[0150]Although SD pixel [be / SD pixel which constitutes the tap / an extremum] which makes a tap constitute based on the error over the dynamic range approximation straight line etc. was determined in this embodiment it is possible to determine SD pixel which makes a tap constitute based on the feature (waveform characteristic) on the waveform of SD pixel which constitutes taps other than these.

[0151]Although SD pixel which makes a tap constitute was determined in this embodiment for [every] all directions which make a central pixel the starting point it is not necessary to necessarily determine the pixel which makes a tap constitute for such every direction.

[0152]Although the image processing device and the learning device which learns the prediction coefficient for every class used with the image processing device were constituted from this embodiment as a separate device it is also possible to constitute these image processing devices and learning devices in one. And it is able to make it to make the prediction coefficient which makes learn to a learning device in real time and is used for it with an image processing device update in real time in this case.

[0153]At this embodiment although it was made to make coefficient RAM5 memorize the prediction coefficient for every class beforehand this prediction coefficient can also be made to supply an image processing device with an inputted image (SD picture) for example.

[0154]A class tap and a prediction tap can also be constituted using the pixel which exists in the direction of space and which direction of a time direction.

[0155]In learning processing as mentioned above the add lump equivalent to the summation (σ) of a formula (7) is performed using a prediction tap but. The add lump using the prediction tap which comprises an SD pixel of a position which sees and is different from a noticed picture element is performed for the pixels to which those prediction taps correspond.

[0156]namely direction D_1 of 16 shown in drawing 3 by this embodiment supposing it constituted the basic tap from 5x5 pixels 25 pixels centering on a central pixel as shown in drawing 3 thru/or D_{16} -- a prediction tap comprises arbitrary pixels on

each. Therefore although it comprises a pixel in a position which regards as a certain prediction tap and other prediction taps from a central pixel and is different. In this case for example in a certain prediction tap the pixel as a tap which is in the 1st from the central pixel of direction D_1 is added in other prediction taps with the pixel as a tap which is in the 1st from the central pixel of direction D_1 .

[0157] Class sorting is also performed from same viewpoint. Namely each pixel (pixel value) as a tap for all directions which constitute a certain class tap for example When equal to each pixel as a tap in the turn of corresponding from the central pixel of a corresponding direction which constitutes other class tap the class sorting result of having used each of the two class taps becomes the same (class sorting is carried out to the same class).

[0158]

[Effect of the Invention] According to the 1st data processing device of this invention a data processing method and the medium like the above. Based on the waveform characteristic of input data two or more data extracted from input data is determined and two or more data is extracted from input data about the attention output data which is output data which is going to calculate a predicted value according to the determination. And the predicted value of attention output data is calculated based on two or more of the extracted data. Therefore it becomes possible to calculate the predicted value near attention output data.

[0159] According to the 2nd data processing device of this invention a data processing method and the medium the student data which serves as a student is generated from the teacher data which serves as a teacher for study of a prediction coefficient and two or more data extracted from student data is determined based on the waveform characteristic of the student data. And about the attention teacher data which is teacher data which is going to calculate a predicted value according to the determination two or more data is extracted from student data and a prediction coefficient is calculated based on two or more of the extracted data. Therefore it becomes possible to obtain the prediction coefficient which can calculate the predicted value near teacher data.

[0160] According to the 3rd data processing device of this invention based on the waveform characteristic of input data two or more data extracted from input data is determined and two or more 1st data is extracted from input data about the attention output data which is output data which is going to calculate a predicted value according to the determination. And the predicted value of attention output data is calculated based on two or more of the 1st extracted data. On the other hand the student data which serves as a student is generated from the teacher data which serves as a teacher for study of a prediction coefficient and two or more data extracted from student data is determined based on the waveform characteristic of the student data. And about the attention teacher data which is teacher data which is going to calculate a predicted value according to the determination two or more 2nd data is extracted from student data and a prediction coefficient is calculated based on two or more of the extracted data. Therefore it becomes possible to calculate the predicted value near attention output data by

using the prediction coefficient.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is a block diagram showing the example of composition of the 1 embodiment of the image processing device which applied this invention.

[Drawing 2] It is a figure showing a basic tap.

[Drawing 3] It is a figure for explaining processing of the tap determining circuit 7 of drawing 1.

[Drawing 4] It is a figure for explaining processing of the tap determining circuit 7 of drawing 1.

[Drawing 5] It is a flow chart for explaining the resolution improvement processing by the image processing device of drawing 1.

[Drawing 6] It is a flow chart for explaining the 1st tap decision processing in Step S1 of drawing 5.

[Drawing 7] It is a figure for explaining the 1st tap decision processing in Step S1 of drawing 5.

[Drawing 8] It is a flow chart for explaining the 2nd tap decision processing in Step S1 of drawing 5.

[Drawing 9] It is a figure for explaining the 2nd tap decision processing in Step S1 of drawing 5.

[Drawing 10] It is a flow chart for explaining the 3rd tap decision processing in Step S1 of drawing 5.

[Drawing 11] It is a figure for explaining the 3rd tap decision processing in Step S1 of drawing 5.

[Drawing 12] It is a block diagram showing the example of composition of the 1 embodiment of the learning device which applied this invention.

[Drawing 13] It is a flow chart for explaining the learning processing by the learning device of drawing 12.

[Drawing 14] It is a figure for explaining the medium which applied this invention.

[Drawing 15] It is a block diagram showing the example of composition of the computer 101 of drawing 14.

[Description of Notations]

1 A frame memory and 2 A class tap generating circuit
3 A prediction tap generating circuit and 4 class sorting circuits
5 coefficient RAM
6 prediction arithmetic circuits
7 tap determining circuit
61 A frame memory and 62 infanticide circuits
63 A frame memory and 64 A class tap generating circuit
65 A prediction tap generating circuit and 66 class sorting circuits
67 An adder circuit and 68 prediction-tap memory
69 adder circuits and 70 Teacher data memory
71 An arithmetic circuit and 72 A tap determining circuit
101 computers and 102 A hard disk
103 Semiconductor memory and 111 A floppy disk
112 CD-ROM and 113 MO disks
114 DVD
115 magnetic disks and 116. Semiconductor memory and 121 A

download site122 A satellite and 131 [An input part and 148 / The
communications department and 149 / Drive] A network and 141 A bus142
CPU143 ROM144 RAM145 input/output interfacesand 146 An indicator and 147
